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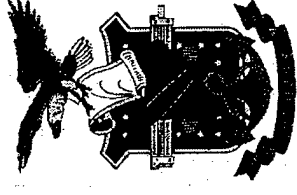# A Comprehensive Approach to Teaching Avionics Systems Flight Test

By

LCDR Doug Lucka,
USNTPS

Mr. Bill Michael,
USNTPS

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Overview

- USNTPS Mission

- Increased Importance of Systems Testing

- How to develop the "End Product"

- Tools and Methodologies

  – Past and Present Approaches

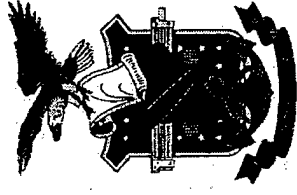 – Challenges

- Summary

USNTPS Mission

- Train:
  - Engineering Test Pilots
  - Engineering Test NFO/Weapon Systems Operators
  - Flight Test Engineers
- To Support:
  - Naval Aviation Systems Team and RDT&E Community

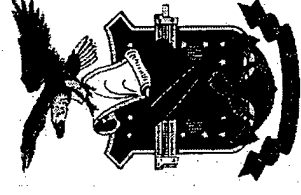UNCLASSIFIED

Why Systems Emphasis?

- Two Factors
  - Legacy/Aging Aircraft
    - Legacy Systems Require Sensor/Avionics Upgrades to:
      - Remain operationally effective
      - Affordable readiness
        - Many current projects are driven by sheer cost of maintaining older, less reliable systems/sensors
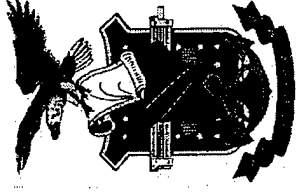
Why Systems Emphasis?

– Shift in DoD Acquisition

- COTS/NDI Acquisition Strategies
  – Typically FOT&E
  – Bulk of NAWC-AD Test Work
  – Management Misperceptions

- Modern Weapons Systems
  – Sub-system upgrades must be approached and tested as a "System" at the System level

- Significant percentage of graduates move on to "Systems Testing"

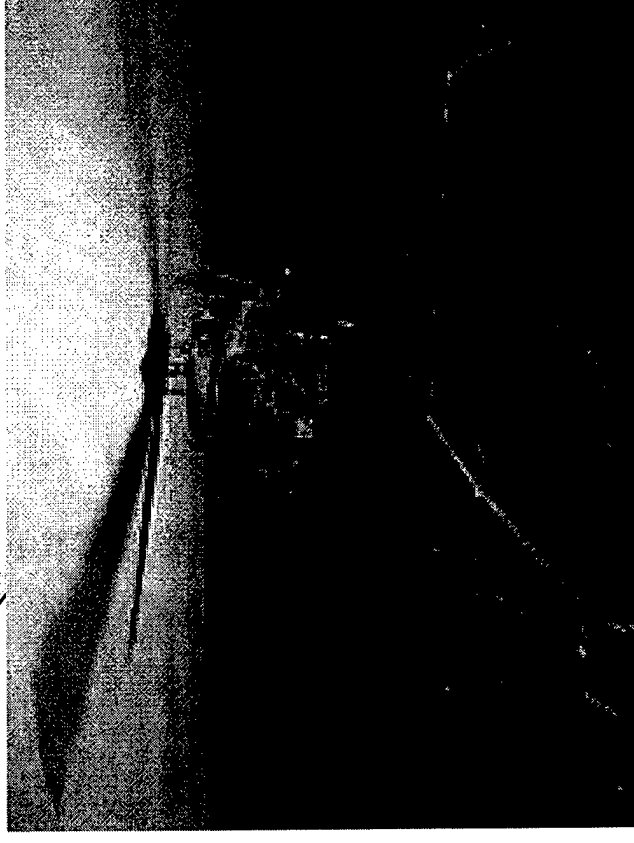UNCLASSIFIED

Why Systems Emphasis?

- NAWC-WD
  - F/A-18 Advanced Weapons Lab
  - Pt. Mugu
- NAWC-AD
  - Test Squadrons
- Many Graduates doing Systems Testing vice Classical FQ&P
  - Still a requirement to Train to FQ&P
  - Customer Feedback - More Systems

Systems Testing

- Full spectrum of testing occurring at NAWC AD/WD
  - Navigation
    - P-3/S-3/F-18/E-2
  - C4I/SR
    - P-3/EP-3E/E-2C
  - Radars
    - V-22
  - EO/IR
    - ATFLIR/SH-60R/ SLAM-ER/ P-3
  - Computers/Software
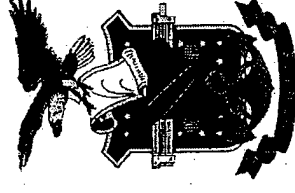   - AV-8B/F-18/S-3/E-2

End Product

- Systems Tester – All Communities/All Positions
  - Pilots, NFOs and Engineers who can approach any Systems Acquisition, and Plan, Execute, and Report Flight Test
  - A "Toolbox" of sound methodologies to approach any Avionics Systems Test Program
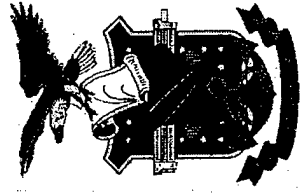 - Support a Program from CE to FOT&E
    - New or COTS/NDI

Inputs to TPS

- Wide Variety of Mission Experience/ Academic Knowledge
  - E-2C to F/A-18 to P-3C to SH-60
  - Pilots, Systems Operators, Engineers
  - Varying Levels of Education
  - B.S. Business, to M.S. in EE, AE -Avionics

Old Approaches

- Systems taught as a separate curriculum
  - Resulted in 2 kinds of test pilots
    - Systems
    - FQ&P
  - Not optimum for productivity/credibility
- Academics directly to Flight with minimal Lab/Simulation
  - A-7/A-4 was the vehicle for training systems

Instructional Approach

Two Tiers of Exposure

Airborne Tactical Aircraft Evaluation

Academic Theory

Classroom

Application of Theory
Students apply theory and test techniques to demonstrate mastery.

Presentation of Theory
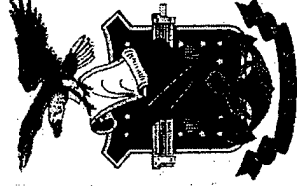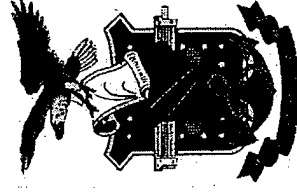Theory supporting T&E is introduced in the classroom.
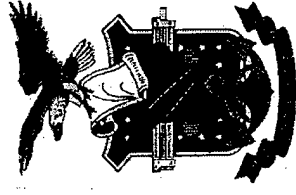
Shift to Current Approach

- Systems and Fixed Wing Academic syllabi joined

- F/A-18's arrive at the School

- Fix the "A" card "B" card problem
  - Teach FQ&P
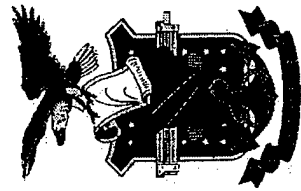 - Solid Basis in Systems

- Increased Lab/Simulation Capabilities

USNTPS Systems Curricula

- A dedicated 48 week Systems Course
  - Naval Flight Officers/Flight Test Engineers
  - Focus is Airborne Systems, but get exposure to classical FQ&P Flight Test
- Fixed and Rotary Wing Pilots get Systems Training
  - Adding depth is a challenge
    - 48 Weeks - Full

Instructional Approach

Multiple Tiers of Exposure

Airborne Tactical Aircraft Evaluation

Airborne Simulator and Laboratory Exercises
Ground-based

Academic Theory
Classroom

Application of Knowledge
Students apply theory and test techniques to demonstrate mastery.

AppliedTheory and Flight Test Techniques
Theory learned in the classroom is combined with FTT in ground-based and airborne simulators and laboratories.

Presentation of Theory
Theory supporting T&E is introduced in the classroom.

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USNTPS Systems Flight Exercise Curricula Relationships
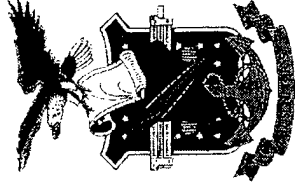
S Systems Exercises
- RCS
  - Radar - Quantitative & Qualitative
  - EO/IR - Quantitative & Qualitative
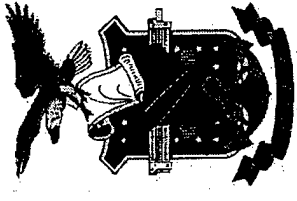 - NVD - Qualitative
  - Navigation - Quantitative & Qualitative

R Systems Exercises
- Radar - Qualitative
- EO/IR - Qualitative
- Navigation - Quantitative & Qualitative

X Systems Exercises
- Radar - Qualitative
- EO/IR - Qualitative
- NVD - Qualitative

Academics

- The "Foundation" which all else builds upon.
- All 3 Curricula get a basic core (first few months)
- Varying Levels between Curricula to Support the Flight Exercises
- Must Transition from the Chalkboard to the Lab
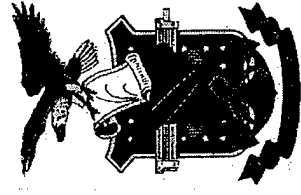
Lab

- Radar and EO/IR as well as basics of RF theory taught in Lab Environment]

- Visualize classroom concepts
  - Full Physics Based Air to Ground Radar Simulator
    - Vary Radar Parameters with software
      - Display things like: Unambiguous range, Blind Ranges, Range/Az Resolutions, etc.
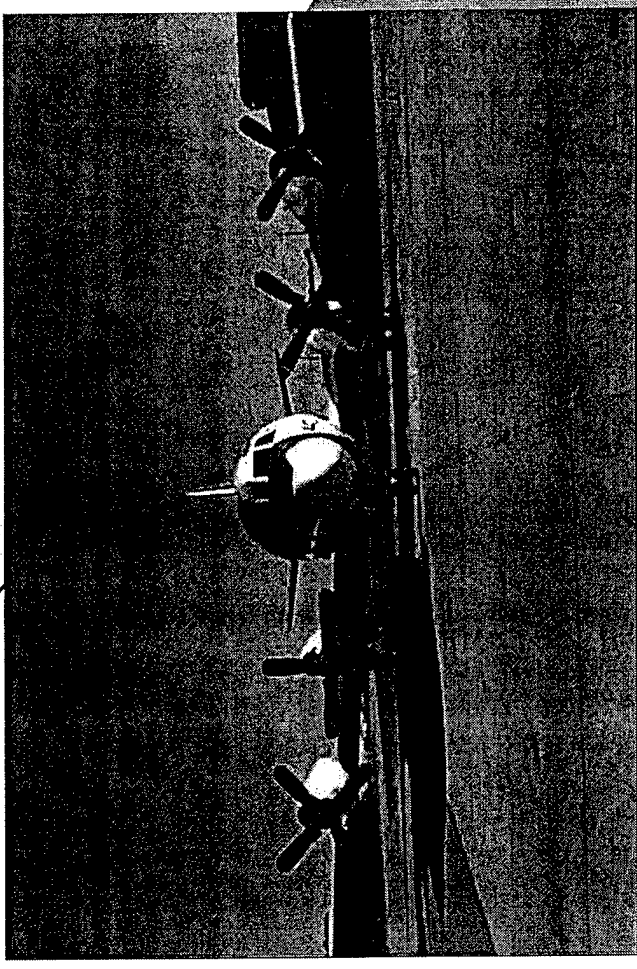 - FLIR/LASER to teach EO/IR Fundamentals
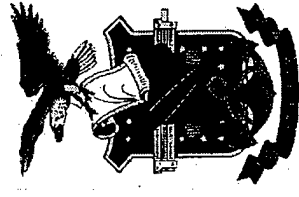
Radar Simulator
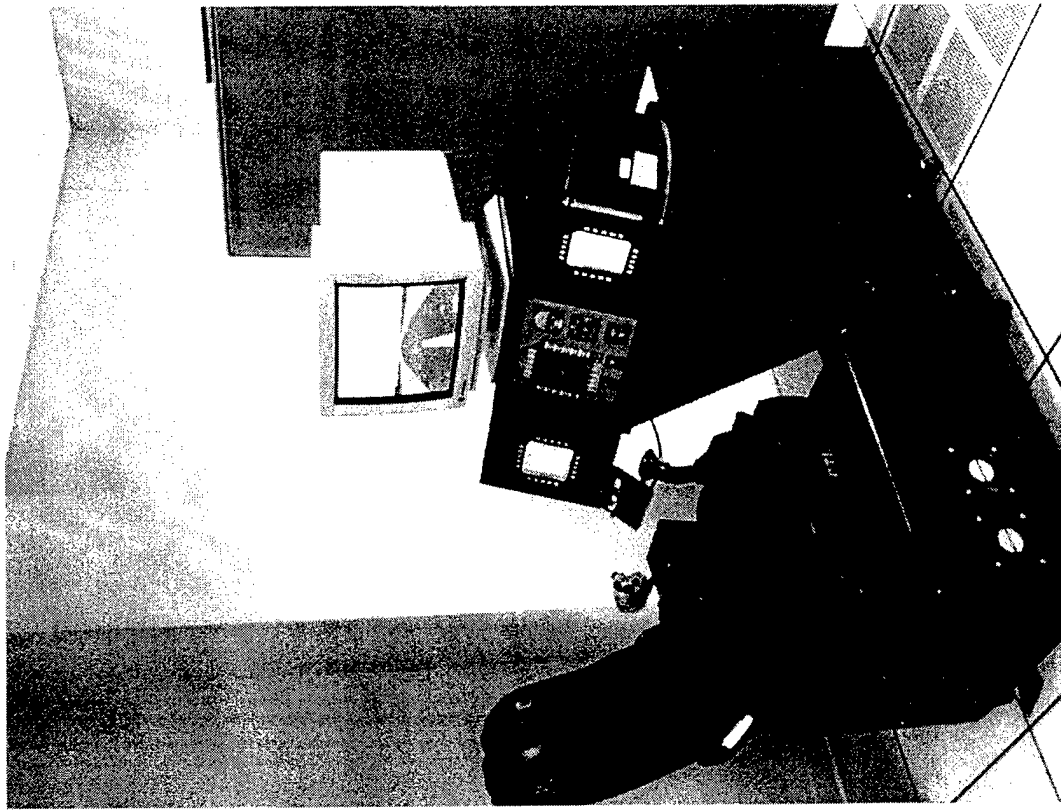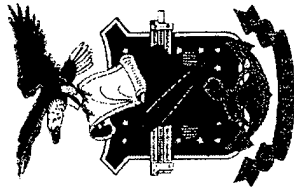
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USNTPS NP-3D
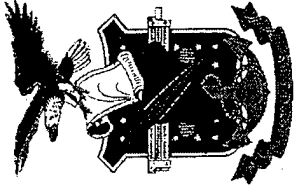
- The key element in USNTPS approach to systems is the NP-3D
  - Formerly a YP-3 Oceanographic Research Aircraft
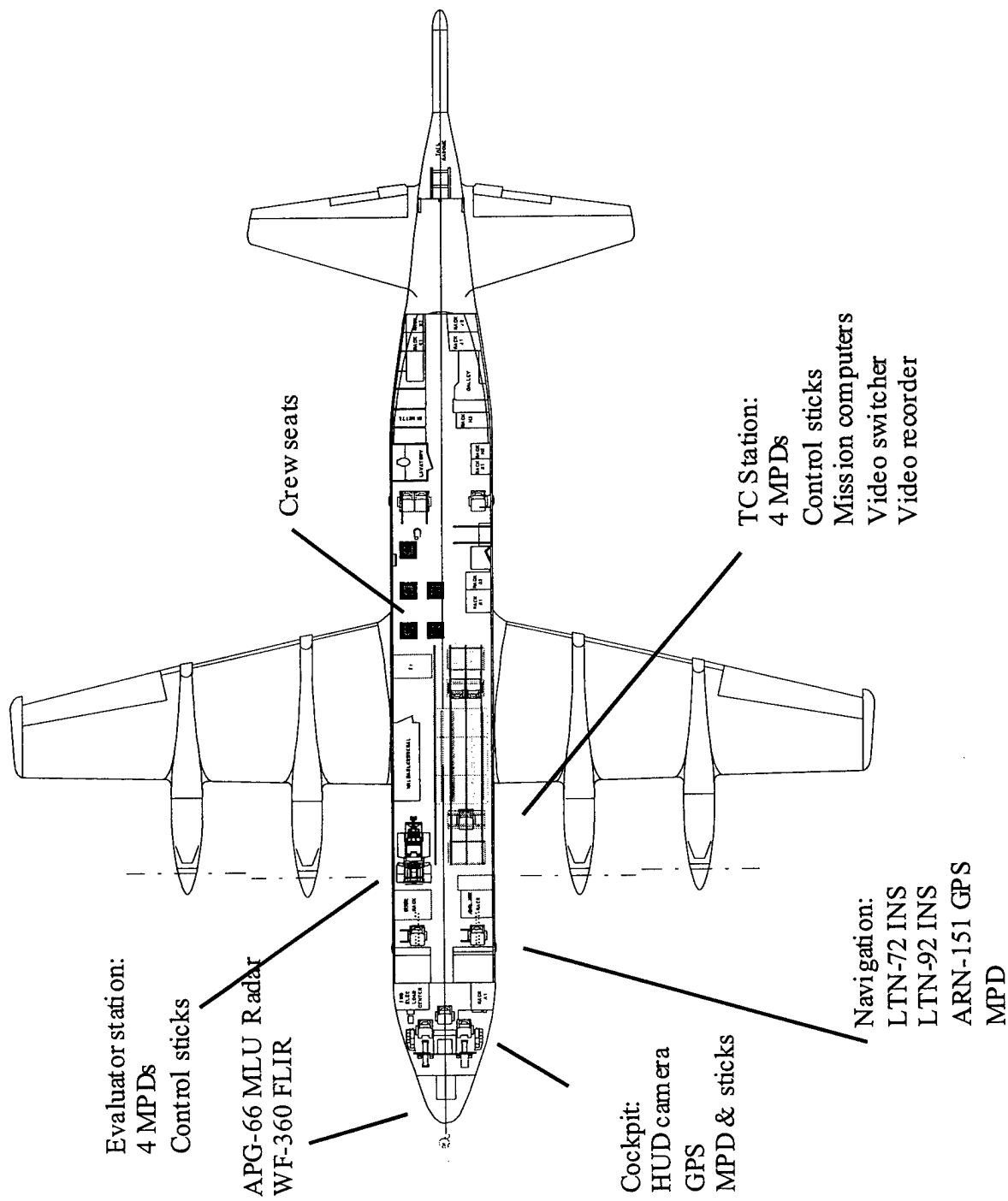 - Converted to an avionics "Test Bed" for use teaching systems test techniques
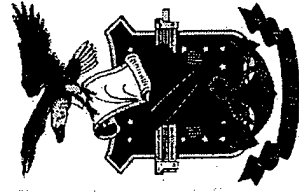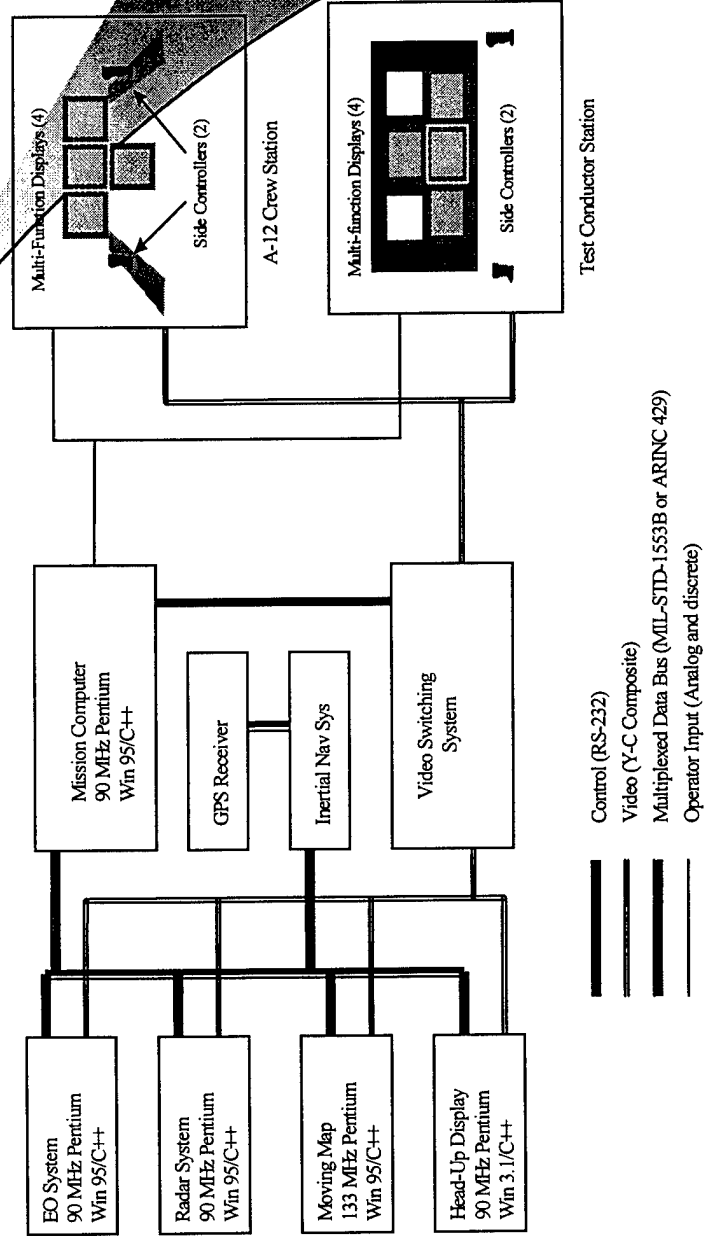
NP-3D Systems

- APG-66(V)2 Mid-Life Upgrade (MLU) Radar
- WF-360TL FLIR/TV/LRF Electro-Optical System
- Moving Map Navigation System
- Simulated HUD Display
- Mission Computer
  - Four interface computers
- Two Crew Stations
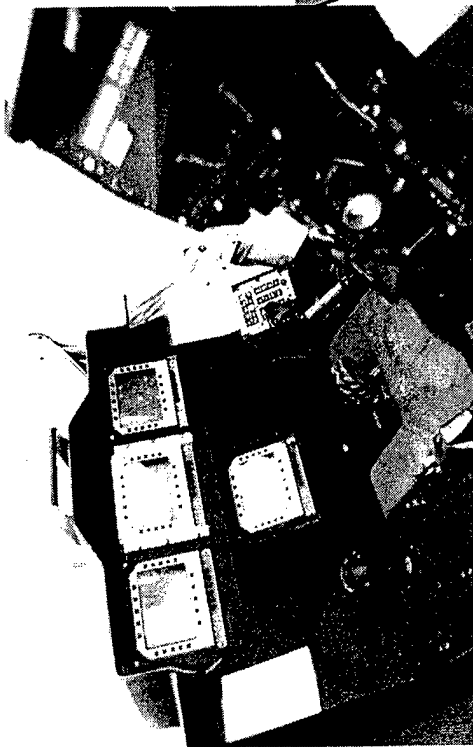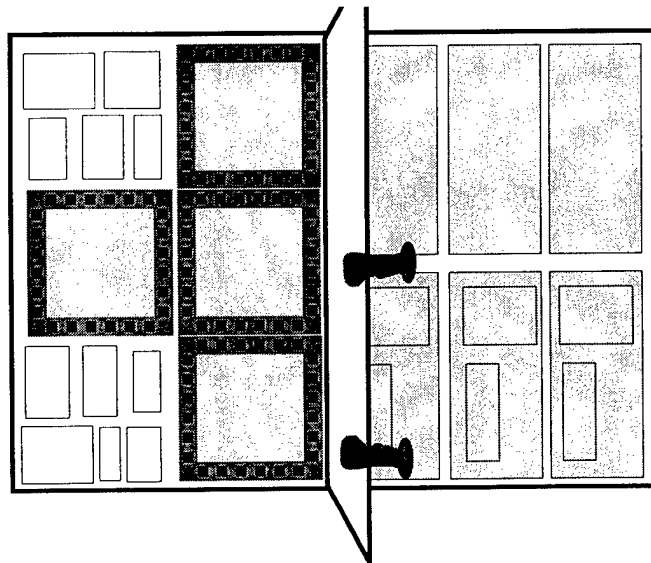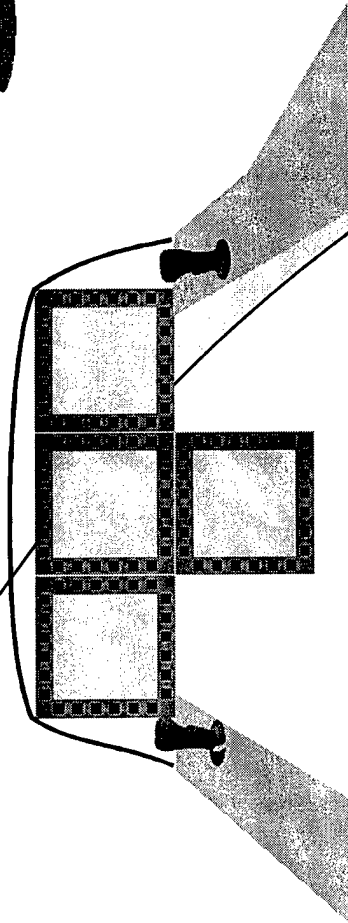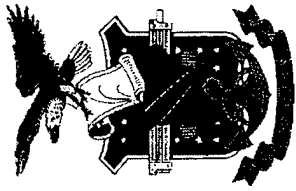 - Test Conductor and Evaluator
- Integrated Navigation System

Crew seats

Evaluator station:
4 MPDs
Control sticks

APG-66 MLU Radar
WF-360 FLIR

Cockpit:
HUD camera
GPS
MPD & sticks

TC Station:
4 MPDs
Control sticks
Mission computers
Video switcher
Video recorder

Navigation:
LTN-72 INS
LTN-92 INS
ARN-151 GPS
MPD

System Architecture

EO System
90 MHz Pentium
Win 95/C++

Radar System
90 MHz Pentium
Win 95/C++

Moving Map
133 MHz Pentium
Win 95/C++

Head-Up Display
90 MHz Pentium
Win 3.1/C++

Mission Computer
90 MHz Pentium
Win 95/C++

GPS Receiver

Inertial Nav Sys

Video Switching
System

Multi-Function Displays (4)

Side Controllers (2)

A-12 Crew Station

Multi-function Displays (4)

Side Controllers (2)

Test Conductor Station

Control (RS-232)
Video (Y-C Composite)
Multiplexed Data Bus (MIL-STD-1553B or ARINC 429)
Operator Input (Analog and discrete)

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ASTARS Stations

Moving Map Display
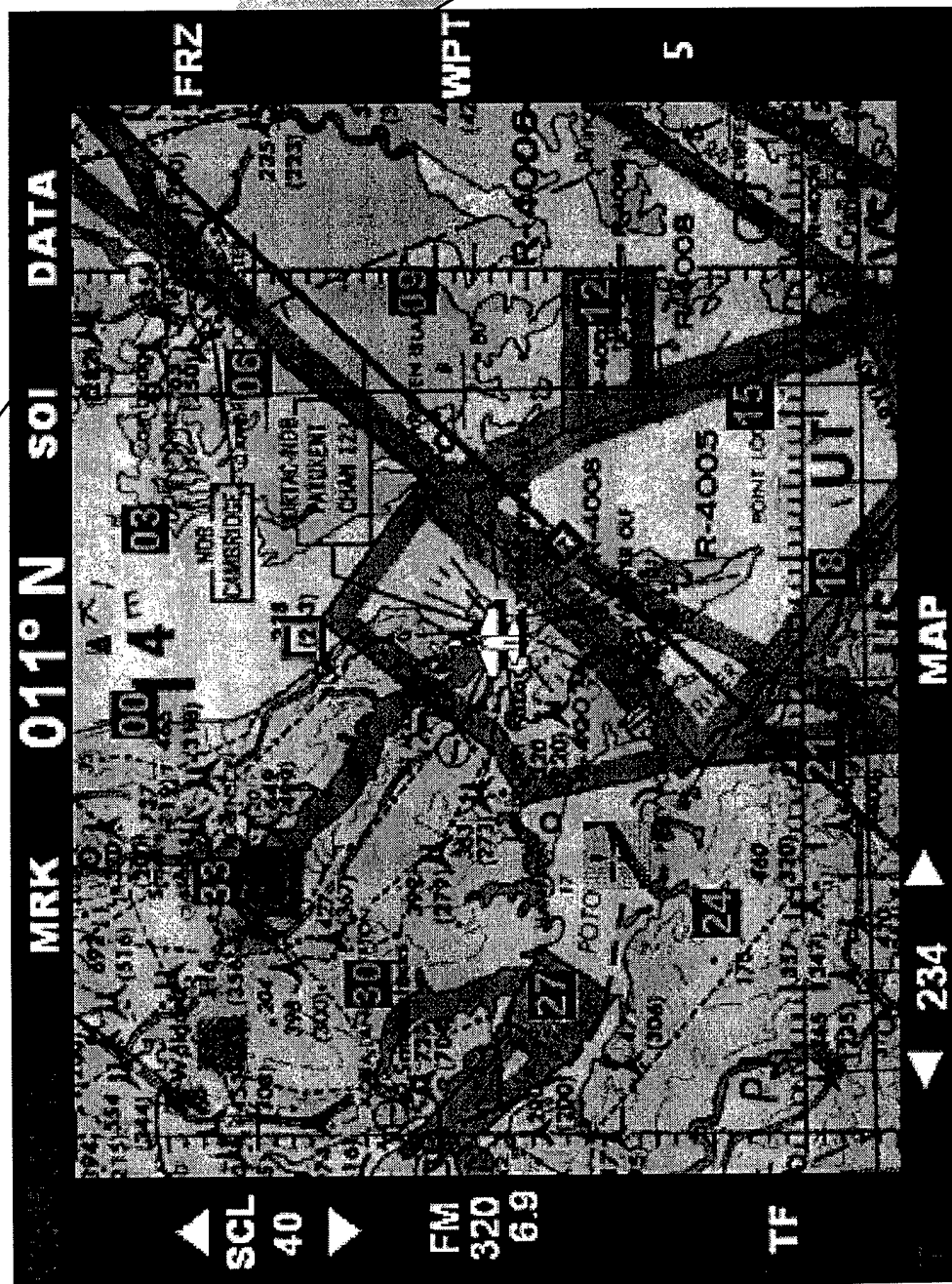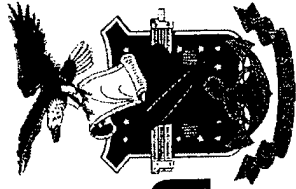
Navigation Instrumentation

Sample Period
10 Min.

Save to floppy
08FE2155

INS Position Errors (relative to GPS)
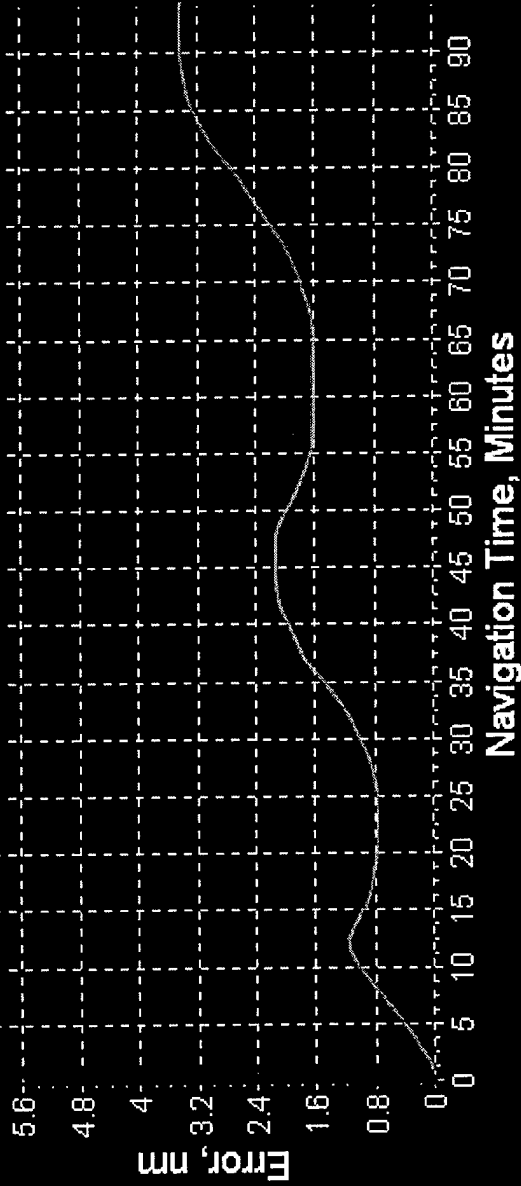
Plot Type
Total Errors

MAP Inst

FLIR/TV Display

HUD Display

004

01

00

4 780

5

4

500

400

472

3.9
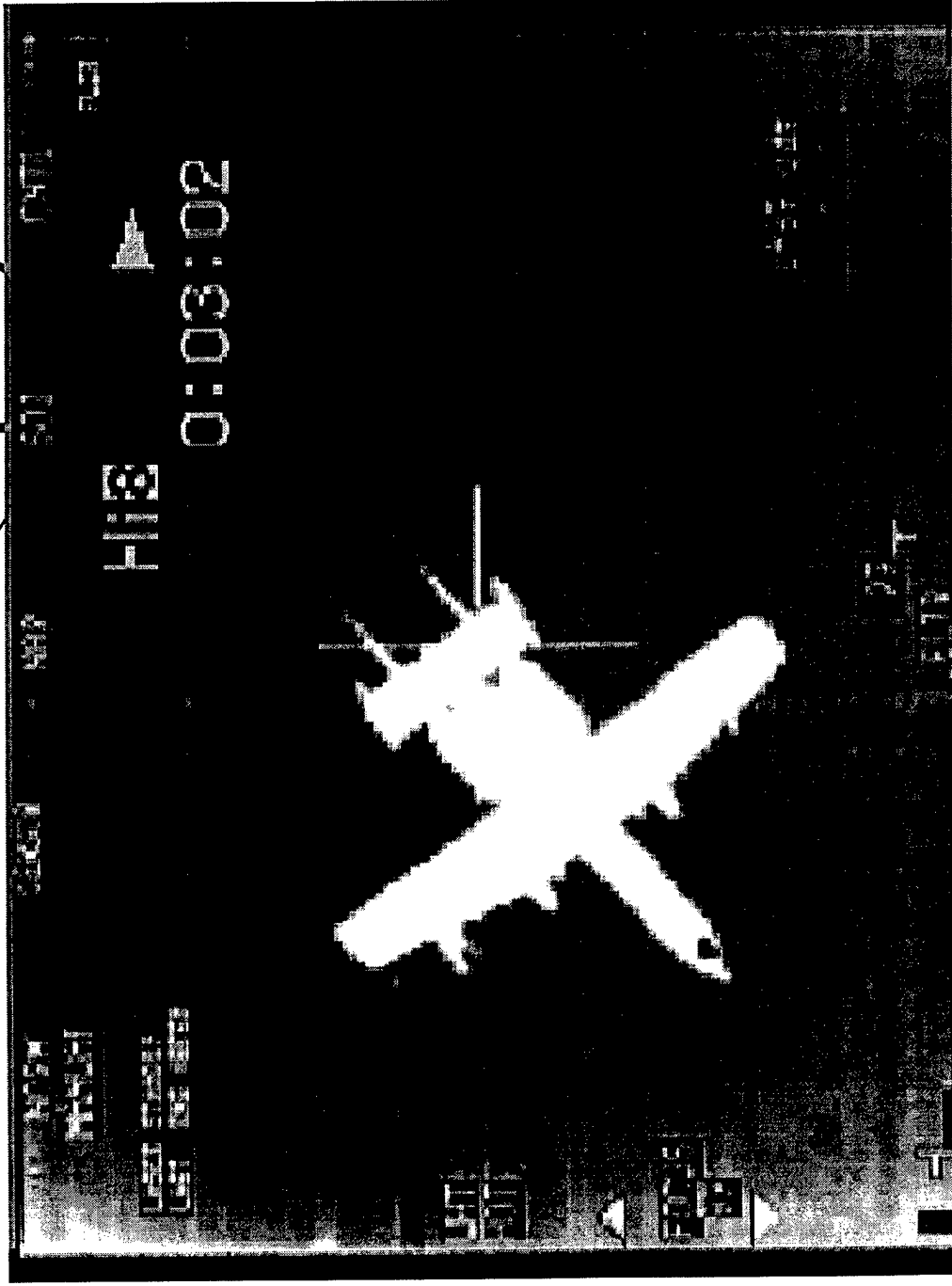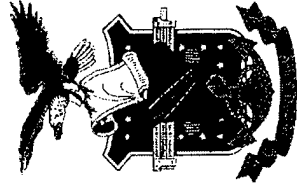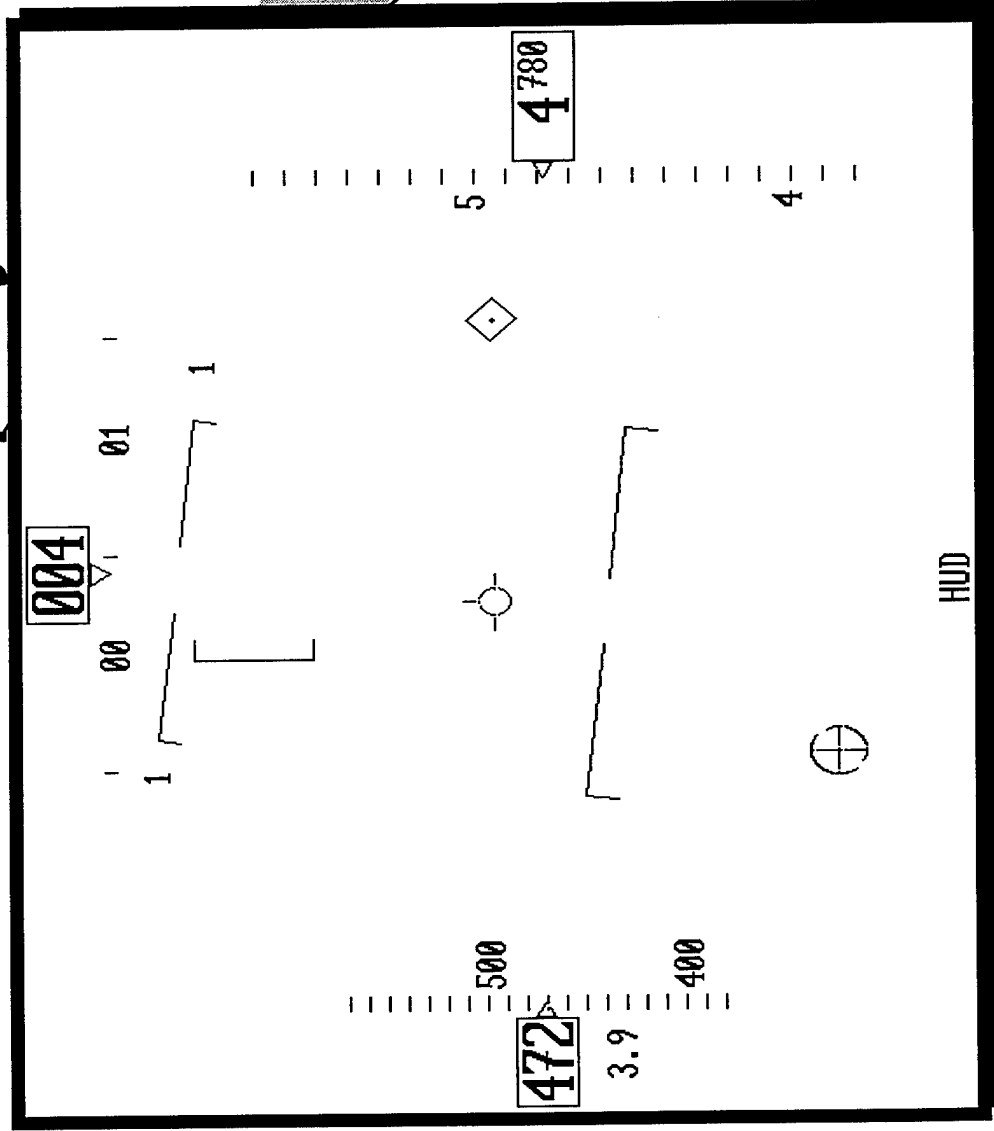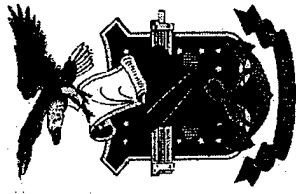
HUD

Air to Air Radar Display

RUS   SOT   CNTL.   352

        500

17L   1395   2395K   0.0

FFT

40

13

089   G

17.0

062

255

261

6.3K

RDR.

40

0.0

A 3

1 B
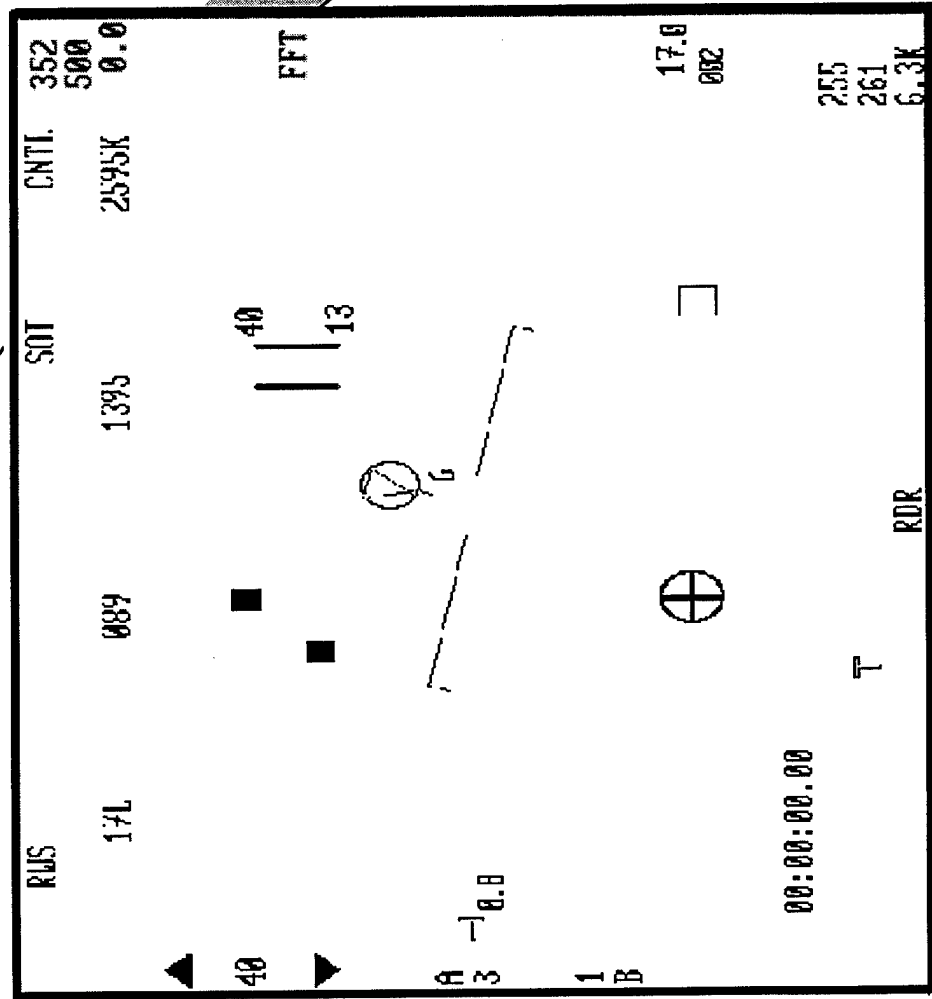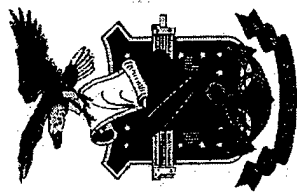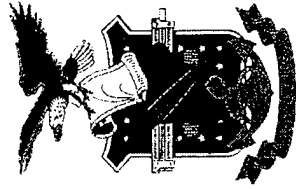
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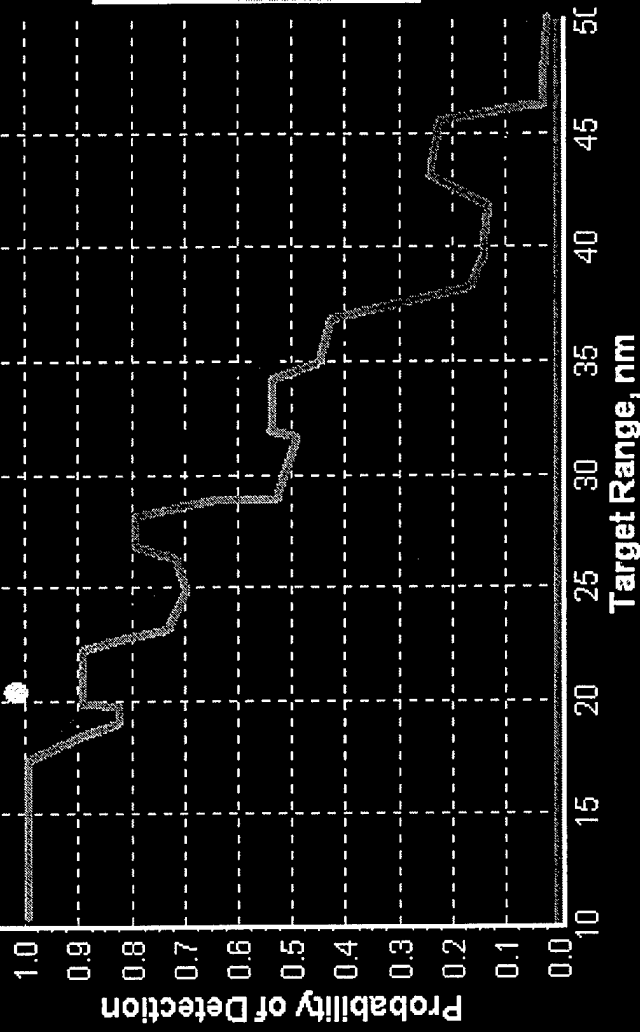
Radar Instrumentation

00:00:00.00

Pd to floppy
17DE0018.PDD

Raw to floppy
17DE0018.BS

RADAR SEARCH PERFORMANCE

Average ━ Current

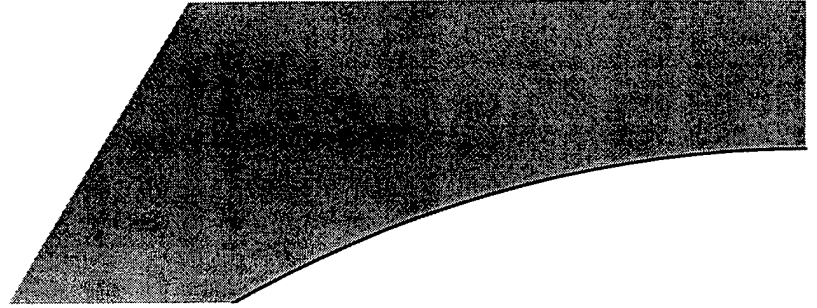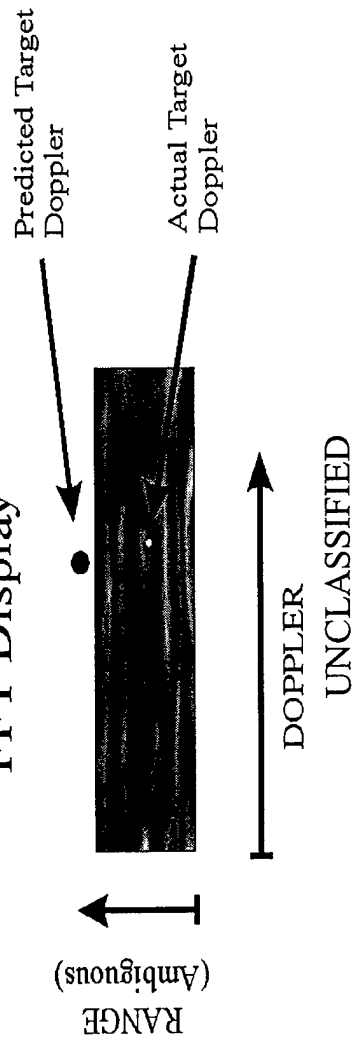FILTER
Tacan

Start

Reset
Average

HUD Pd

(Graph: Probability of Detection vs. Target Range, nm)

Air-To-Air Search FFT Display

CFAR Detections

SAM Reacquisition Range

Cursor Range

DOPPLER

RANGE (Ambiguous)

Saturations
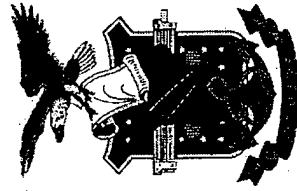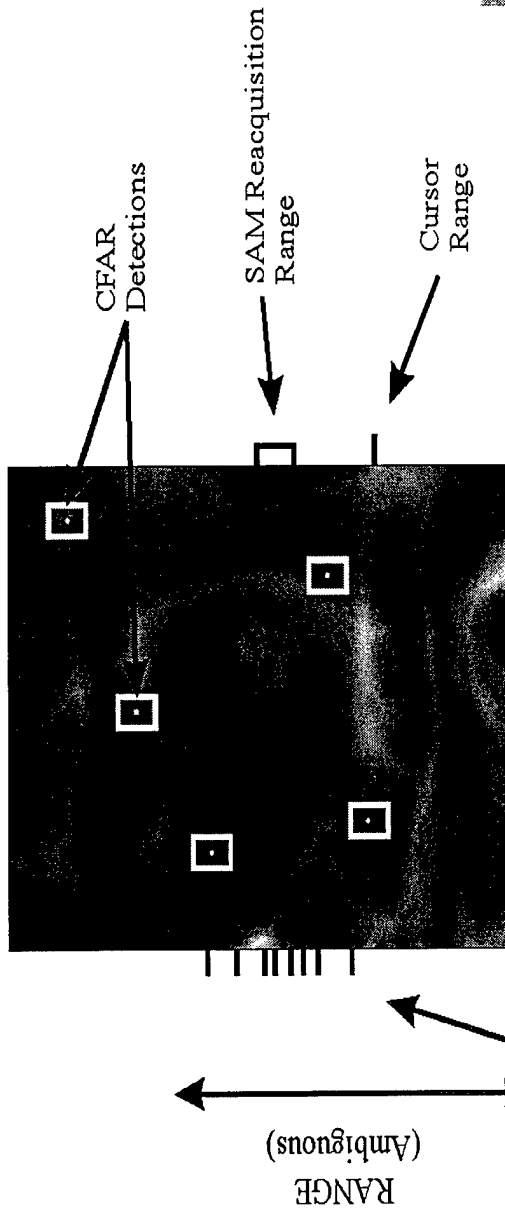
Air-To-Air Track FFT Display

Predicted Target Doppler

Actual Target Doppler

DOPPLER

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RANGE (Ambiguous)
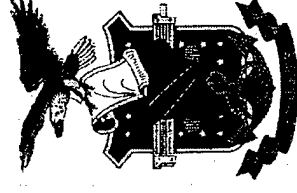
Integration

- Systems are highly integrated
  – Slave to/from each sensor
- Teaches Integrated Systems Concepts to aircrew from non-integrated platforms
- Introduction to Basic HOTAS concepts
- Instrumentation allows for deeper investigation of Radar Processing than in our production F/A-18's
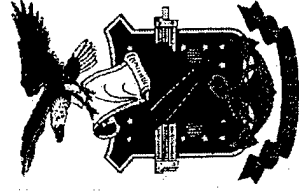
ASTARS Bridges the Lab to Advanced System
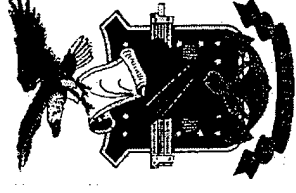
- The ASTARS allows instruction of Flight Test Techniques in a "Classroom" environment in the air.

- Learn and execute the fundamentals of Systems Flight Test in a more benign environment

- Is the build-up to the other advanced systems testing

Instructional Approach

Multiple Tiers of Exposure

Application of Knowledge
Students apply theory and test techniques to demonstrate mastery.

Airborne Tactical Aircraft Evaluation

AppliedTheory and Flight Test Techniques
Theory learned in the classroom is combined with FTT in ground-based and airborne simulators and laboratories.
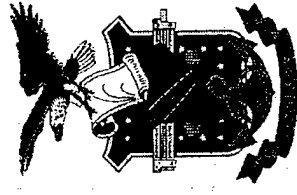
Airborne Simulator and Laboratory Exercises
Ground-based

Presentation of Theory
Theory supporting T&E is introduced in the classroom.

Academic Theory
Classroom

Recent Syllabus Changes

- Instrumentation/Radar Capabilities of the MLU Upgrade have allowed for deeper theoretical T&E of the APG-66(V)2.

  – Systems students performs an in-depth radar evaluation using on-board instrumentation

  – Fly an F/A-18 OT Prep Exercise

  – Rotary Wing using for Radar Evaluation

  - Test Techniques and a more advanced radar system than in the SH-60B
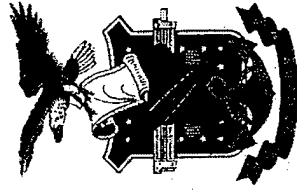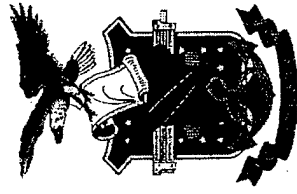
Recent Syllabus Changes

- Fixed wing use ASTARS to learn Radar Test Techniques
  - Fly a team Radar Test Evolution in the F/A-18
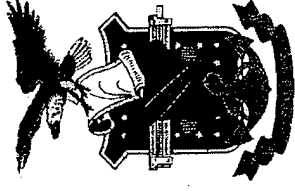
Future Plans for ASTARS

- Develop a comprehensive Software T&E Exercise
- Add Captive Weapons Seekers
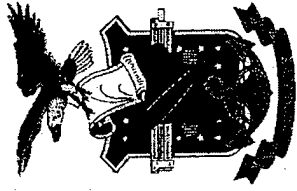 - Fold into current EO/IR

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Summary

- One new start
  - JSF
  - CSA
  - No new Systems - integrate legacy weapons systems
- Systems will continue to be the majority of T&E
  - Upgrades, Add-ons, ATD, Tech Insertion
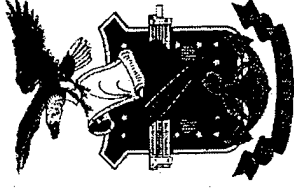 - Pressure to cut T&E time/cost

Summary

- Software complexity exploding
  - Teach a sound standard methodology

- Flying Lab/Classroom is the most effective way develop the end product

QUESTIONS ???